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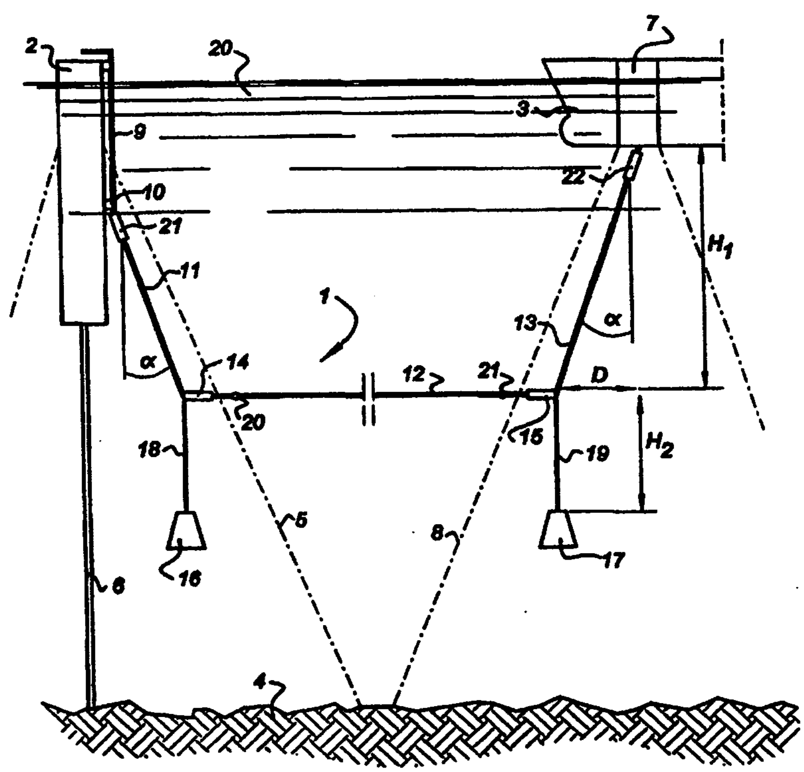
(54) Title: TRANSFER PIPE SYSTEM

(57) Abstract

The invention relates to a transfer system for transfer of fluids, such as hydrocarbons between two floating structures. The transfer system of the present invention comprises two generally vertically oriented duct sections (11, 13) which are placed at an angle (alpha) with the vertical. These two sections are connected to a substantially horizontal third member (12), for instance a third duct section. Near the connection points of the vertically oriented duct sections (11, 13) and the horizontal member (12), a tensioning weight (16, 17) is provided such that a tensioning force in the horizontal duct section is created. Hereby bending/kinking and/or buckling due to currents or floating systems dynamics is reduced. A relatively long horizontal duct section can be used which is preferably made of hard pipe, having a reduced swing.



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Transfer pipe system.

The invention relates to a transfer system for transfer of fluids from a first floating or fixed structure to a second floating structure, the transfer system comprising a first and second duct section connected to the first and second structures respectively, and a substantially horizontal, submerged, third duct section interconnecting the first and second duct sections.

It is known to connect two floating offshore structures via a transfer duct system for conveying hydrocarbons from one structure to the other. One floating structure may be a production or storage structure such as a spar buoy, a semi-submersible structure, a fixed tower or a mooring buoy whereas the second structure may comprise a floating production storage and offloading vessel (FPSO), a shuttle tanker and the like. Such a system is described in Dutch patent application NL-A-8701849. In the known configuration, a production platform is anchored to the seabed via radial taut mooring lines, the platform being connected to a subsea well head via a riser. The production platform is connected to a mooring buoy via flexible duct sections. The duct sections are anchored to the seabed via tethers. The mooring buoy is connected to the seabed via a cable carrying at the end thereof a clump weight. The clump weight is anchored to the seabed via an anchor chain. The mooring buoy can freely drift within an area that is defined by the length of the anchor chain between the clump weight and the sea bed. The tanker that is moored to the buoy can weathervane around the buoy and is subject to drift in accordance with prevailing wind and current conditions.

From US patent number 4,339,002 a discharge manifold system is known wherein a flexible conduit extends vertically downwards from a production platform to below waterlevel, continues horizontally and extends vertically upward towards a mooring buoy which is anchored to the seabed.

The known systems have as a disadvantage that the duct sections may be subjected to bending/kinking or buckling due to currents which may displace the system sideways. In view of the connection of the shuttle tanker to the freely moving mooring buoy, the influence of the floating system dynamics on the transfer ducts is limited but the system is relatively complex in view of the additional mooring buoy being required. Furthermore, in view of the freedom of movement of the tanker, there is

a risk of the tanker damaging the transfer pipes.

An alternative option to connect two floating structures is to run the transfer pipes down to the seabed and back up in order to avoid current and floating system-induced forces. Such a system however is not practical in deep water, for instance at depths of 1000 metres below sea level or more.

It is therefore an object of the present invention to provide a transfer system in which the bending or buckling due to currents and floating system dynamics is reduced and which has a relatively small swing. It is another object of the present invention to provide a transfer system which can bridge a large distance between the interconnected structures. It is a further object of the present invention to provide a transfer system which can be produced in an economic manner.

Hereto the transfer system according to the present invention is characterised in that the horizontal member is near its ends provided with tensioning members oriented in a substantially vertical direction, at least one tensioning member being inclined at an angle (α) with respect to the vertical, a tensioning weight being connected at or near the ends of the horizontal member for providing a tensioning force on the third duct section.

Because of the inclination of at least one of the vertically positioned tensioning members, the ballast weight exerts a horizontal component on the substantially horizontal third duct section. Hereby it is kept from bending or buckling and has a reduced swing due to the restoring force created by the counterweight when it is offset from its equilibrium position. Furthermore, the system according to the present invention does not require additional mooring constructions and allows to use relatively long, substantially horizontal duct section, having a length of for instance 3000 metres.

With "substantially horizontal" it is meant that the third duct section does not make a larger angle with the horizontal than at most 45°.

According to the invention it is possible to either integrate the tensioning member in either one of the first or second duct sections or embodying the tensioning member as a separate article.

In the first embodiment because of the tension, the related first or second duct section will generally extend according to a straight line. In the second embodiment the first and/or second duct section can have any shape.

This is dependent from its length relative to the length of the tensioning

member as well as its weight. For example the related first or second duct section can comprise three parts, one substantial vertical part and other substantial horizontal part connected by a transitional part.

In one embodiment both first and second tensioning members are inclined with respect to the vertical, a tensioning weight being provided at or near each connecting point of the first and second duct sections with the third duct section. By using two tensioning weights, one at each end of the horizontal duct section, an even tension force can be applied on the horizontal duct section.

Preferably the first and second duct sections and/or tensioning members are attached to the third duct section via an articulation joint, such as for instance a flex joint or a pivoting joint. In one embodiment the duct sections are made of hard pipe which allows for a relatively economic manufacture. The use of hard pipe in this case is possible as the bending and buckling in the present system is reduced due to the tensioning effect of the weights. When hard pipe is used, the system of the present invention may be used in relatively large water depths such as 100-150 metres below sea level and deeper. It is possible to use however a combination of hard and flexible duct sections. Multiple transfer systems of the present invention may extend in a radial manner from a single floating structure, such as the spar buoy, to respective FPSO-tankers or buoys for export. The buoyancy of the tensioning weights may be adjustable for instance by ballasting the counter weights with water or deballasting using compressed air. Additional weight could also be added or removed. The third duct section may be provided with buoyancy such as to have a neutral or even positive buoyancy in water.

Embodiments of the transfer system according to the present invention will, by way of example, be described in detail with reference to the accompanying drawings. In the drawings:

Figure 1 shows a side view of the transfer system according to a first embodiment of the present invention;

Figure 2 shows a top view of the system of figure 1 in the absence of a sideways current;

Figure 3 shows a top view of the system of figure 1 wherein the horizontal duct section is displaced by a sideways current and

Figure 4 shows schematically the side view of a further transfer system

according to a further embodiment of the present invention,

Figure 5 shows an embodiment wherein the horizontal duct section is connected to a floatation member, and

Figure 6 shows an alternative tensioning construction.

Figure 1 shows a mid-depth transfer system 1 according to the present invention connecting a spar buoy 2 to a floating production storage and offloading (FPSO) vessel 3.

The spar buoy 2 is anchored to the seabed 4 via anchor lines 5. One or more risers 6 connect the spar body to a subsea hydrocarbon well. The vessel 3 comprises a geostationary turret 7. The turret 7 is via a chain table, which extends near keel level of the vessel 3, connected to the seabed 4 via mooring lines 8. The vessel 3 can weathervane around the turret 7.

From the production tree at deck level of the spar buoy 2, one or more pipes 9 extend, for instance via a guide 10 at the outer perimeter of the spar body, to an inclined duct section 11. The inclined duct section 11 is connected to a horizontal duct section 12 which at its other end is connected to a second inclined duct section 13. The inclined duct section 13 is connected to the turret 7 of the vessel 3. The inclined duct sections 11,13 are connected to the spar buoy 2 and the vessel 3 respectively via flexible joints 21,22.

The horizontal duct section 12 is connected to the inclined duct sections 11,13 via pivot joints or flexible joints 14,15. At or near the joints 14,15 tensioning weights 16,17 are attached via cables 18,19. The tensioning force exerted by each weight 16,17 is proportional to sin α, wherein α equals the angle of inclination of the substantial vertical duct sections 11,13. Although it is shown in figure 1 that the angles α of the duct sections 11,13 are equal, this is not necessary and different inclinations may be used when differing weights 16,17 are used. Furthermore, it is not necessary that the duct section 12 is exactly horizontal but it may be offset from the horizontal. The horizontal duct section 12 may be located from a few metres, up to 150 metres or more below sea level 20.

The angle of inclination α may for instance be about 30°. The height H1 between the flexible joints 21,22 and the attachment point of the weights may be for instance 115 metres. The horizontal distance between the flexible joints 21,22 may be about 2173 metres whereas the length of the horizontal duct section 12 may be about

2000 metres. The length of each inclined duct section 11,13 is about 173 metres. The weight of each tensioning weight 16,17 can be for instance 100 t. The diameter of the ducts 11,12 and 13 may be for hard pipe for instance 0,5 metre.

As the dynamic motions of floating vessels during storms can be large, the vertical motion transferred to duct 12 by way of duct 11 or 13 may cause unacceptable bending stresses near the ends of duct 12. To alleviate this bending, an additional articulated pivot or flex joint 20,21 may be installed perhaps 10 to 100 m from the flexible joints 14,15.

As shown in figure 2, in the absence of sideways current all duct sections 11,12 and 13 will extend along a substantially straight line.

Due to a sideways current in the direction of the arrow c, as shown in figure 3, the horizontal duct section 12 is somewhat displaced and the distance L between the two tensioning weights 16,17 is decreased compared to the distance L in the absence of a current, which has been indicated with the dashed lines in figure 3. Hereby the horizontal duct section 12 will assume a curved or bend shape. The distance L of the section 12 can for instance be between 1000 and 10.000 metres.

As the tensioning weights 16,17 exert a tensional force on the horizontal duct section 12, the amount of buckling remains limited. Furthermore, the excursion of the horizontal duct section from its straight position will be limited due to the additional tensional restoring force of the tensioning weights 16,17 when they are placed in their offset position, as shown in figure 3. For the distance L of 2173 metres, the amount of sideways deflection B may be about 300 metres at a sideways current of about 1 m/s. In this case the angle of inclination α will increase from 30° to about 35°. The horizontal tensioning forces in the horizontal duct section 12 amount to about 52 tons whereas the vertically directed component of the tensioning weight 16,17 amounts to about 31 t.

Fig. 4 shows a further embodiment of the invention wherein the mid-depth transfer system is referred to by 31 and connects two vessels 32 and 33. From the production tree at deck level of vessel 32 one or more pipes 39 extend to a duct section 41. This duct section 41 is connected to a horizontal duct section 42 comprising a long multiple pipe bundle which can either be rigid or flexible. This horizontal duct section 42 is at its other end connected to a second duct section 43 being connected to vessel 33. From vessel 32 and 33 tension members 34,35 extend to a connection

36,37 on the third duct section. These tension members can comprise a chain cable or any other tension member known in the art. The long multiple pipe bundle 42 is provided with further connections 38, 39 to which weights 46 and 47 are connected.

Each of the first and second duct sections is no longer tensioned as in the embodiments according to fig. 1-3 wherein the tensioning member is integrated in the first and second duct section. Because of that the first and second duct section will have the shape as shown, i.e. comprising a first substantially vertical part and a third substantial horizontal part connecting to the third duct section. Inbetween is a transisitional part.

The person skilled in the art will understand that all alternatives given with regard to the embodiment discussed relating to figs. 1-3 can be introduced in the embodiment of fig. 4 and vice versa. Furthermore further changes of the structure discussed above are possible being obvious for the person skilled in the art without leaving the scope of protection which is conferred by the appended claims.

In the embodiment of figure 5, the horizontal, third member comprises an elongated buoyancy element 50, with several chambers which is tensioned by tension members 34,35 and weights 46,47. The buoyancy element 50 serves as a structional support for the ducts 42.

In the embodiment of figure 6 the tension members 34,35 comprise polyester cables, attached to the seabed. Cable 35 is connected to a winch 51 and the vessel 33.

Claims

1. Transfer system (1,31) for transfer of fluids from a first fixed or floating structure (2,32) to a second floating structure (3,33), the transfer system comprising a first and second duct section (11,41,13,43) connected to the first and second structures respectively, and a substantially horizontal, submerged member (12,42,50), interconnecting the first and second duct sections (11,41,13,43), characterised in that the third member (12,42,50) is near its ends provided with tensioning members (11,13,34,35) oriented in a substantially vertical direction, at least one tensioning member being inclined at an angle (α) with respect to the vertical, a tensioning weight (16,17,46,47) being connected at or near the ends of the horizontal member for providing a tensioning force on said member (12,42,50)

2. Transfer system according to claim 1, characterised in that the horizontal member comprises a third duct section (12,42).

3. Transfer system (31) according to claim 1 or 2, characterised in that the tensioning member is formed by at least one of the first and second duct sections (11,13) is oriented in a substantially vertical position and being inclined at a predetermined angle (α) with respect to the vertical, a tensioning weight (16,17) being connected to the transfer system at or near the connecting point (14,15) of the inclined duct section (11,13) and the substantially horizontal third duct section (12) for providing a tensioning force on the third duct section.

4. Transfer system (31) according to claim 1, wherein the tensioning member (34,35) comprises a line, connecting the horizontal duct section (42) to its respective structure (32,33).

5. Transfer system (1,31) according to claim 4, wherein at least one of the first and second duct sections (41,43) comprises a first substantially vertical part, a second transitional part and a third substantially horizontal part.

6. Transfer system (1,31) according to any of the preceding claims, wherein both first and second duct sections (11,13) or lines (34,35) are inclined with respect to the vertical, a tensioning weight (16,17,46,47) being provided at or near each connecting point (14,15) of the first and second duct sections (11,13) with the third duct section (12), or each connecting point (36,37) of each line (34,35) with the third duct section (42).

7. Transfer system (1,31) according to any of the preceding claims, wherein the first and second duct sections (11,13) are attached to the third duct section (12) via an articulation joint (14,15).

8. Transfer system (1,31) according to any of claims 1 to 7, wherein the first and seco.nd duct sections (41,43) and the lines (34,35) are attached to the third duct section via a articulation joint.

9. Transfer system (1,31) according to any of the preceding claims, wherein the first and second duct sections (11,41,13,43) are attached to the respective fixed and/or floating structures (2,32,3,33) via an articulation joint (21,22).

10. Transfer system (1,31) according to any of the preceding claims, wherein the duct sections (11,12,13,41,42,43) are made of hard pipe.

11. Transfer system (1,31) according to any of the preceding claims, wherein at least two parallel third duct sections (12,42) are connected to the first and second duct sections (11,41,13,43).

12. Transfer system (1,31) according to any of the preceding claims, wherein at least two spaced apart first and third duct sections (11,41,12,42) extend from the first structure (2,32), each being connected at or near a respective second floating structure (3,33) via a respective second duct section (13,43).

13. Transfer system (1,31) according to any of the preceding claims, wherein the downwards force of the tensioning weight (16,17,46,47) is adjustable by weight or buoyancy.

14. Transfer system (1,31) according to any of the preceding claims, wherein the buoyancy of the tensioning weight (16,17,46,47) is adjustable.

15. Transfer system (1,31) according to any of the preceding claims, wherein the third duct section (12,42) is provided with buoyancy.

16. Transfer system according to any of the preceding claims, wherein the third duct section (12,42) comprises a hard pipe duct section having flexible pipe section or articulations (20,21) therein to reduce bending.

Fig 1

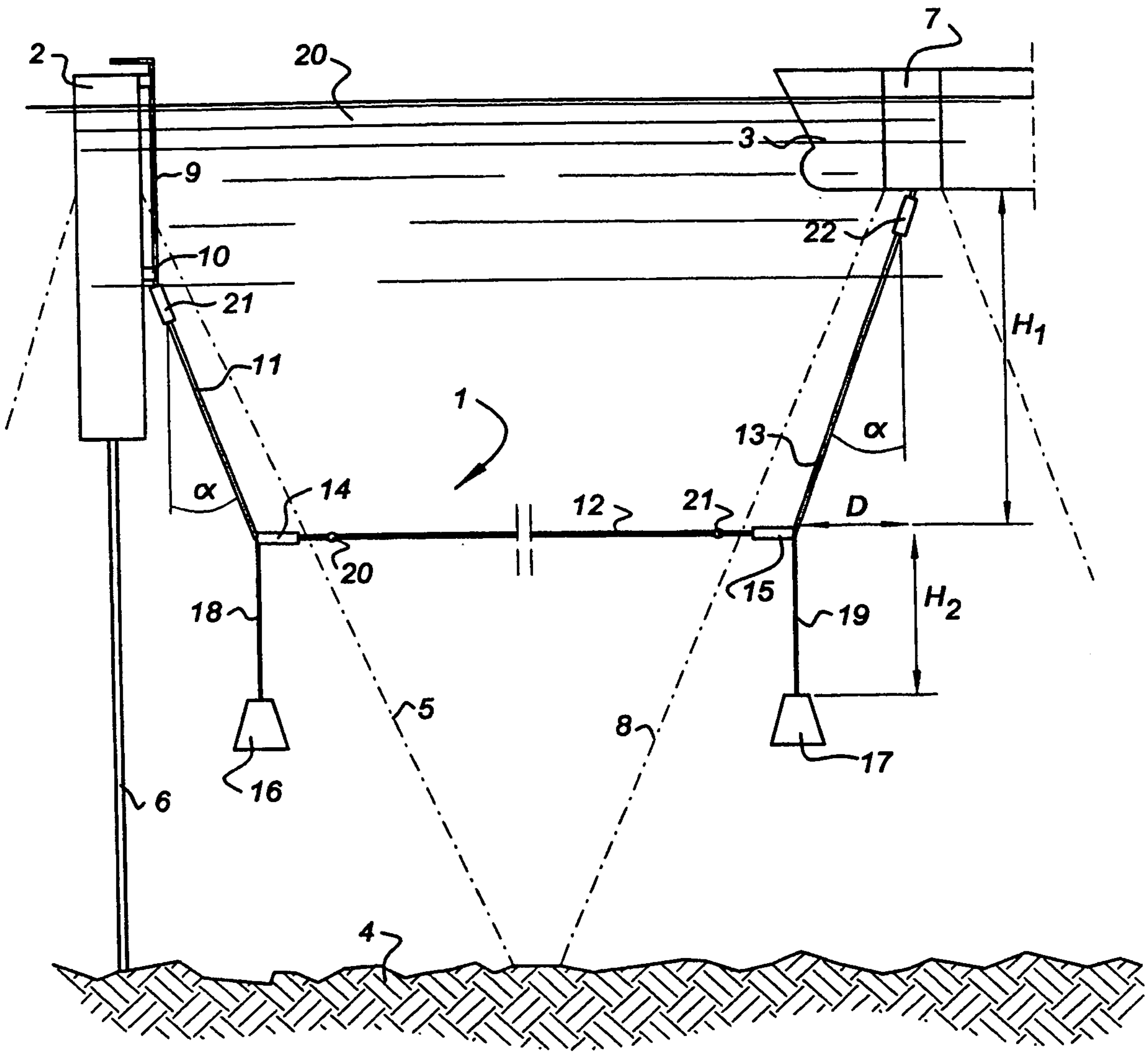


Fig 2

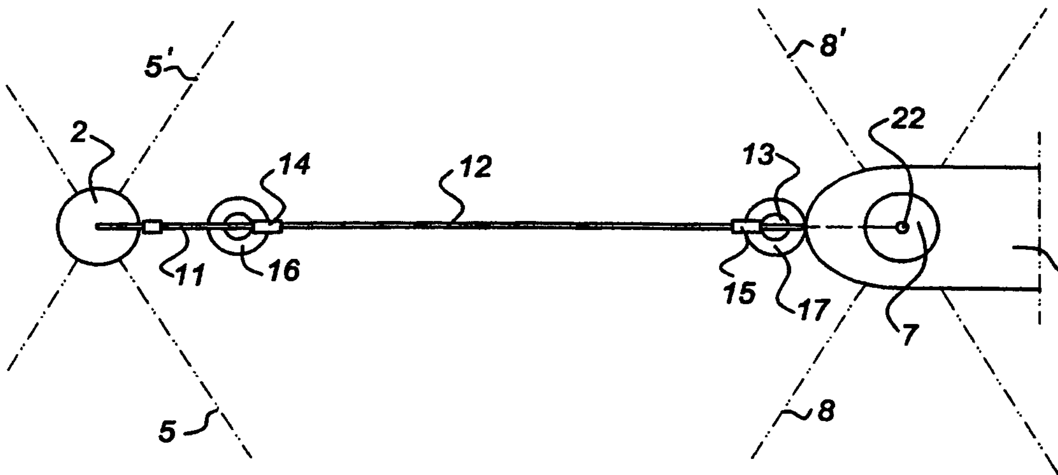


Fig 3

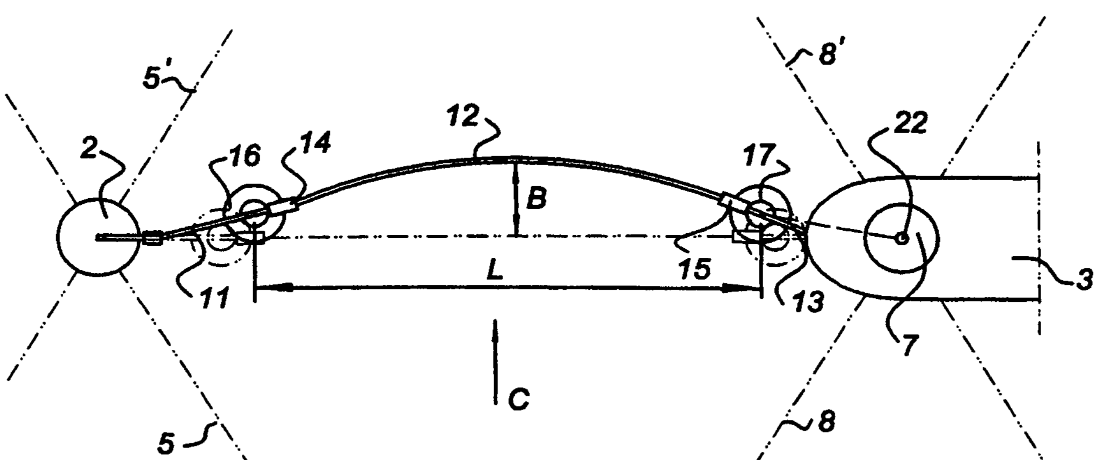


Fig 4

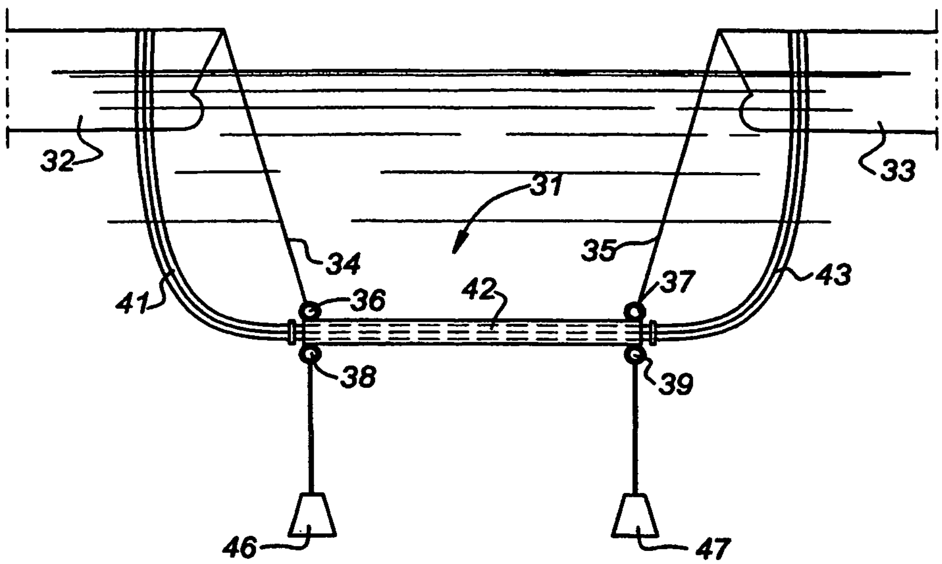


Fig 5

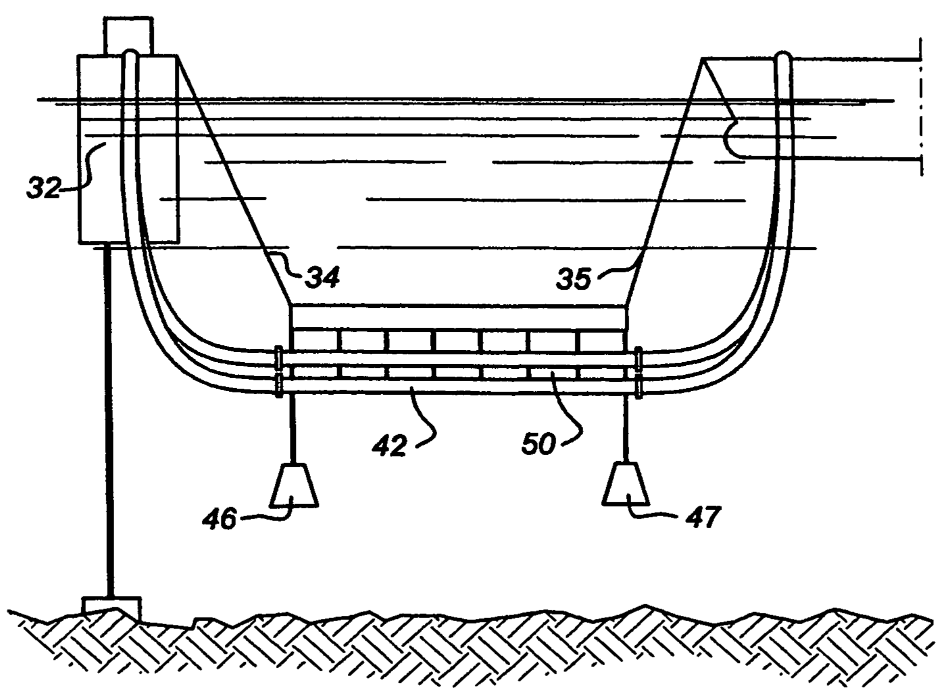
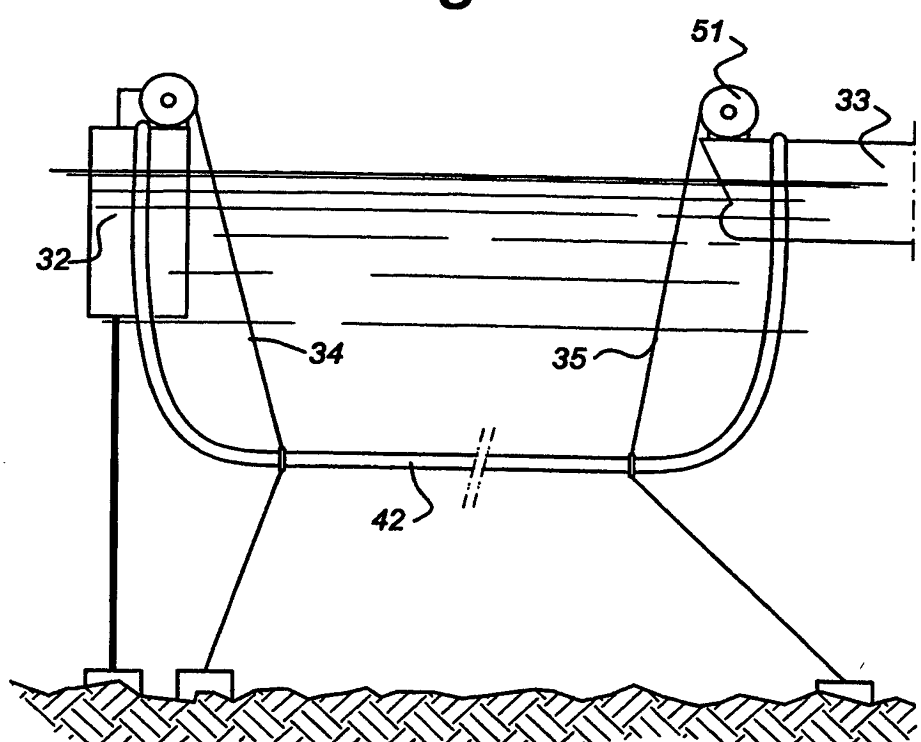


Fig 6



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B63B22/02

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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